

between the limits $+20^{\circ}$ and -20° , so that we don't possess its corrections for lower temperatures.

In order to reduce the alcohol thermometers to the terms of the international hydrogen thermometer, to all readings made on alcohol thermometers, before their being published in the Annals for 1892, corrections were applied, as they were obtained by Mr. Hlasek from comparisons of the thermometer, Geissler No. A, belonging to the Observatory, with the normal thermometer Tonnelot, purchased by the Observatory and verified in the International Bureau of Weights and Measures. The corrections were—

| | | | | | |
|-----------------|------------------|------------------|------------------|------------------|------------------|
| At..... | -20° C. | -30° C. | -40° C. | -50° C. | -60° C. |
| Correction | 0.0° | -0.6° | -1.1° | -1.6° | -2.0° |

From direct comparisons of the readings of the alcohol thermometers with those of the mercury ones, made at several stations in the district of the Observatory in the interval -30° to -40° it follows, that these corrections ought not have been applied to the alcohol thermometers on most stations, for the readings of the alcohol thermometers differ in the above-mentioned interval in general very little from the readings of the mercury thermometers.

Therefore since 1893 the above-stated corrections were no more applied to the readings of the alcohol thermometers and for low temperatures only additional corrections were used, obtained from direct comparisons of the alcohol thermometers with the mercury ones, belonging to the stations.

Owing to these reasons I suppose, that the correction -2.0° C. should not have been applied to the readings of the alcohol thermometer No. 81*, in Verkhoyansk in 1892; as we do not know the true corrections for the thermometer No. 81* in the interval -30° to -70° , it would be more appropriate to use its direct readings without any additional correction. The lowest temperature of air in Verkhoyansk ought therefore to be considered as -68° C [-90.4° F.], it is also the lowest temperature which has ever been observed on the stations of our meteorological net.

As for the value -72° , which Prof. Voelkov gives in his work, it is most probably due to a misunderstanding; it seems, that he added the correction -2.0° once more to the already-corrected reading of the alcohol thermometers, published in the Annals of the Observatory for the year 1892.

Yours truly,

[Signed] B. GALITZIN.

551.524 (744)

NOTES ON THE HOT WAVE IN SOUTHERN CALIFORNIA. JUNE 14-17, 1917.

By FORD ASHMAN CARPENTER, Meteorologist.

[Dated: Weather Bureau, Los Angeles, July 12, 1917.]

Record June temperatures were experienced generally in southern California during the four days ending June 17, 1917. As this heat wave was unique in the meteorological history of this section of the United States, both in its distribution and effects, some notes have been collected on the subject and are here presented for future reference and study.

Contributing causes of hot waves in southern California—Mr. G. H. Willson gives the following explanation of hot waves in California.¹

In the late spring, summer, and early fall, when highs cover the North Pacific States and Plateau region, light to moderate, north to east winds prevail over California, and the cool ocean influences are checked or held back. The sky is clear and insolation is great, and the air is heated dynamically in moving down the mountain slopes, causing very high temperatures in the valleys and coast sections. When these conditions are very marked they produce hot waves.

And the present writer, in discussing a hot wave which occurred at Los Angeles on September 17, 1913, gave the following explanation:²

The cause of this hot spell, like all instances of temperatures above 90° in this portion of southern California, was a well-defined "norther" condition brought about by pressure distribution typical of such phenomena.

On September 15 the barometric pressure was high over the Northwest and low in the Southwest. While the low area remained stationary for many days, the high area progressed in a southeasterly direction. The greatest difference in pressure was coincident with the warmest day, when the weather map showed a gradient of a tenth of an inch in barometric pressure to the hundred miles on an east-and-west line.

General weather conditions accompanying the hot wave.—The hot wave of June, 1917, extended over a period of four days; the first indication that a period of warm weather was imminent occurred with the weather map of the 11th, which showed the arrangement of high and low areas typical to such conditions. Up to this date the season had been backward, the weather being cool and cloudy. The ensuing week brought a rapid balancing of the temperature deficiency which was of long standing. At Los Angeles the temperature reached 100° twice in the four days June 14-17, with the maximum of 105° on the 17th. (See fig. 1.) The highest temperature of which we have data, 124° F., was registered at Mecca, Riverside County, on the 15th, and the lowest maximum, 87° , occurred at San Diego. Except along the immediate coast section the mean maximum temperature for southern California for the four days approximated 100° .

Southern California is specially fortunate in having a number of stations equipped with thermographs. In perusing the thermograms from 16 stations it is found that they fall into two general classes: one (illustrated by fig. 2) where the crest of the hot wave was reached on the fourth day; and the other (see fig. 3) where the temperature suddenly touched the highest point on the first day and thereafter steadily diminished. Among stations falling in the first class belong Los Angeles, Pasadena, Mount Wilson, Redlands, Riverside, Corona, Upland, Pomona, San Bernardino, and Santa Barbara. The second class includes San Diego, Escondido, El Cajon, Bonita, Tustin, and Whittier.

Incidental phenomena were associated with the hot wave. The influence of the hot wind at midnight of the 16-17th (see fig. 4), which traversed the seaward side of the mountain range and caused the temperature to rise 15 degrees, is shown at El Cajon, San Bernardino, and Redlands. This hot wind was also felt at many of the desert stations farther south. Another accompanying phenomenon was the effect of the neighboring forest fires on the otherwise equable littoral weather of Santa Barbara (see fig. 5). Special meteorological observer G. W. Russell at that station is probably correct in attributing the abnormal temperatures there to the forest fire. Concerning this phase of the hot wave Mr. Russell says:

¹ Weather Forecasting in the United States, Washington 1916. p. 338. (W. B. No. 583.)

² The September hot wave in Los Angeles, Cal. MONTHLY WEATHER REVIEW, Washington, Sept., 1913, 41:1404.

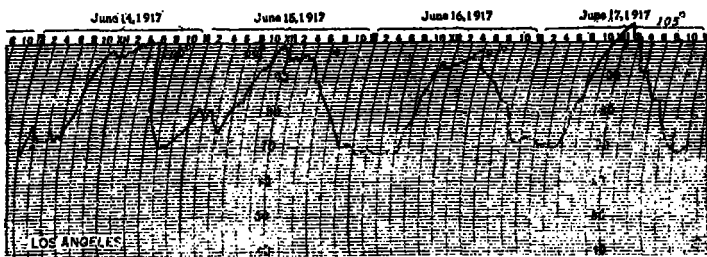


FIG. 1.—Thermogram recorded at U. S. Weather Bureau, Los Angeles, Cal., June 14-17, 1917.

Similar records at Mount Wilson, Pasadena, and other stations within 25 miles of the shore show the same general characteristics.

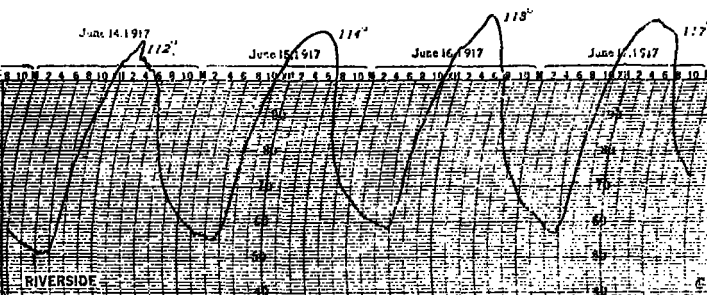


FIG. 2.—Thermogram recorded at Riverside, Cal., June 14-17, 1917.

Similar records at Corona, Upland, Pomona, and the greater portion of the citrus district show the same general characteristics.

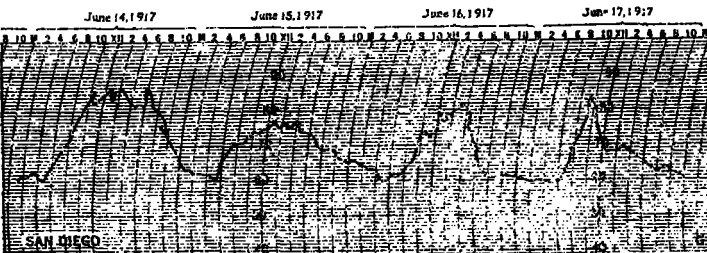


FIG. 3.—Thermogram recorded at U. S. Weather Bureau, San Diego, Cal., June 14-17, 1917.

This curve, with its maximum temperatures on the 14th instead of the 17th, as elsewhere in southern California, is also characteristic of Escondido, Tustin, Whittier, and Bonita, although these stations registered much higher temperatures than these at San Diego.

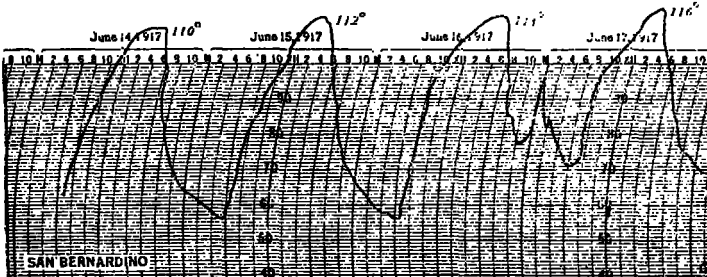


FIG. 4.—Thermogram recorded at San Bernardino, Cal., June 14-17, 1917.

Note the effect of the northeasterly wind about midnight of the 16th-17th. Similar effects were recorded at the same hour at Redlands and at El Cajon, San Diego County; El Cajon, is about 90 miles south of San Bernardino and a little over 10 miles north-east of San Diego.

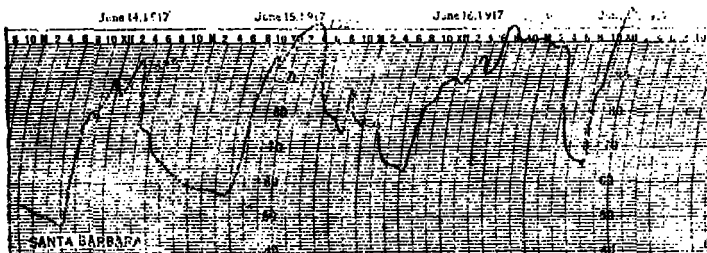


FIG. 5.—Thermogram recorded at Santa Barbara, Cal., June 14-17, 1917.

Note the disarrangement of the daily temperature march, due to forest fires burning within a few miles of the station. Once before, in the past 50 years, has Santa Barbara had such high temperatures, also in connection with forest fires.

If my memory is to be credited, this is the second very hot spell during my life here (Santa Barbara, Oct. 15, 1867, to June 22, 1917); the first spell was about the same time as the Chicago fire (Oct. 9, 1871), when this valley was burned over and considerable damage was done to growing fruit, etc. [On that occasion] apples were cooked on the fire side of the trees, beans and other vegetables were so severely burned that they did not grow again. Birds were often noticed to fly into dwellings to get relief from the heat. One saloon keeper said a little bird flew into a pitcher of water on his bar and nearly drowned in its effort to get water. As there were no instruments in use here there was no means of accurately stating the temperature. I do not remember that any strong wind accompanied that hot spell. Two permanent streams, never before dry, were entirely dry during the two days' heat, but started running again soon after.

This last hot spell was greatly augmented by very strong northeast wind blowing over the forest fire directly toward this city. Many gusts, I estimate, reached a velocity of at least 40 to 45 miles per hour. Of course the anemometer was not capable of recording such a velocity.² As to the temperature of the day unaffected by the fire heat, would say that very near this city the temperature near the beach and where the winds from the fire did not affect the temperature, was not unusually high, say about 80° to 85°. The ocean water temperature was not appreciably raised beyond that of ordinary summer days. Swimmers said that it seemed even colder than usual, so they plunged in very carefully.

There have been very many hot spells here during my 50 years' residence, and four years ago the record showed a temperature of 108°, which I think is the highest ever recorded, up to that time.

Saturday, June 16, 1917, forest fires were burning at many points around us here, and the direction of the wind was such as to bring the heat directly across this depression. For some unexplained cause the growing crops, unless walnuts, were not materially affected, and it is believed the beans will entirely recover with the fogs and be very little if any worse for the heat.

Effect of the hot wave on vegetation.

Press comments on the hot wave.—The California Cultivator of June 30 said:

* * * Some lemons of nearly picking size were actually cooked and the tissue immediately broken down. Others had when cut much the same appearance as frosted lemons. Valencias were softened so that picking ceased for several days. They are now returning to normal condition and shipping is resumed. Walnuts suffered greatly, a large number most exposed to the afternoon heat being burned so that they dropped from the trees. The more protected nuts, however, are yet apparently all right. * * *

But with the loss there are some compensations. For instance, one very large orchard company reports that the heat has wiped out practically all black scale from its trees.

The lemon injury is far less serious than would appear at first thought. Nine-tenths of the lemon crop for the season has been harvested. Of that remaining on the tree, the later fall picking, which usually commands good prices, will yet be marketed. It was feared at first that these under half-sized lemons would drop from the tree, but the drop has proved much less serious than at first anticipated, and, unlike the full-grown lemon, the young fruit seems to show less breaking down of the tissue and less injury.

Navel oranges in orchards on very light, sandy soils, and which possibly were suffering for moisture, have shown very severe dropping. Others, especially where well irrigated shortly before the heat, are yet carrying the greater proportion of their crop. Young fruit of Valencias, that is, the crop for next year, shows much less effect of heat than does the navel.

As to the walnut crop, very thorough canvasses of the situation has been made by the California Walnut Growers' Association, and the following notice is being sent to the trade:

"Southern California has experienced the hottest spell of weather reported for forty-odd years. During the period from June 14 to 17, inclusive, temperatures ranged from 111° to 123° in the shade in the principal walnut-producing districts. This freakish spell caught the walnuts at a very tender stage before the shells had hardened, and simply cooked a large percentage of them. We have just completed a very thorough investigation of the damage with the following results: Santa Barbara County 5 per cent damage, Ventura County 20, Los Angeles County 25, Orange County 35.

"As the largest productions are in Orange and Los Angeles Counties, the average damage for the entire crop is close to 25 per cent, but as we had a prospect for the greatest production on record, we will still apparently ship about as many walnuts as were marketed last year. * * * We feel confident that our prediction of the damage will prove sufficiently high and that it is as accurate as it is possible to obtain."

² Character of instrument not known to the Editor, and not recorded in the Climatological Division, Weather Bureau.

Strawberries and other small fruits suffered from injury to ripening fruit, but young fruit is now coming on and the market is abundantly supplied. Potatoes and beans lacking in moisture at the root suffered, but the great bulk of the crop is in fine condition.

Summarizing the effect of the hot wave on farm products it is generally conceded that the most serious loss will be the navel orange crop, which in some sections is almost a complete loss. Other varieties of oranges were not seriously damaged. Lemons were injured in instances where a considerable amount of mature fruit was on the trees. Much of such fruit was burned while hanging on the trees. Fortunately the greater part of the lemon crop had been picked prior to the period of great heat, so the damage loss is confined to autumn lemons. In this connection it may be remarked that lemon trees are continually in blossom, bud, and fruit. The citrus trees, as such, were not injured. Walnuts had a splendid setting prior to the heat wave, and, while the loss has been considerable, it is believed that the net gains this season will exceed those of last year. Garden truck withstood the heat very well; only early tomatoes were seared; in one district a crop of tomatoes valued at \$50,000 became a total loss. Had the heat wave been preceded by several weeks of normally warm weather, vegetation would have accustomed itself to the steadily increasing temperature, but the suddenness of the mounting temperatures and the steadiness of the drying winds followed too closely upon months of cool, moist weather.

Observations at Mecca date garden.—At the United States cooperative date garden at Mecca, Mr. Bruce Drummond, the official in charge, states that following the high temperature of 124°F. on June 15, 1917, a wind averaging 12 miles per hour began at noon and continued for five hours. The relative humidity during the period between 12 noon and 5 p. m. averaged 6 per cent as determined by a sling psychrometer. He states that this wind was desiccating in the extreme, burning up both vine and root in the vineyards; but it did no harm to the dates. One unirrigated date palm decreased 6 millimeters during the drying wind but within 24 hours regained its former diameter. Drummond also states that observations showed that the wind frequently seemed to come in vertical gusts and that the vineyard was burned in spots. An interesting feature during this hot spell (which exceeded all others in severity during the 12 years that the date farm has been in existence) was that the electric fan did not seem to alleviate the distressing physical effect of the heat.

Comparison with previous hot waves in southern California.

Table 2 gives a comprehensive idea as to the frequency and distribution of heated terms in this district. Although the records are from one station only (Los Angeles), they may be taken as indicative of general prevailing conditions south of the Tehachapi Range and a little distant from the coast. Leaving out a consideration of physical discomfort, it is only when the hot spells occur during the late spring or at the beginning of summer months that damage to farm products occurs. There is no doubt but that the hot wave under consideration was the most damaging to fruits and nuts ever experienced in southern California. The closest previous approach to the meteorological conditions which attended this phenomenon occurred on June 24-28, 1883, when the daily maximum temperatures at Los Angeles were 95°, 98°, 100°, and 90° F, respectively. Tradition has it that the spring of 1820 also saw damaging hot winds which destroyed grain and pasture.

TABLE 1.—Highest and lowest temperatures at stations in southern California during the hot wave of June 14-17, 1917.

| Stations. | | Dates. | | | |
|---------------------|--------------|--------|-----|-----|-----|
| | | 14 | 15 | 16 | 17 |
| | | °F. | °F. | °F. | °F. |
| Bonita..... | Highest..... | 110 | 89 | 93 | 94 |
| | Lowest..... | 55 | 54 | 54 | 57 |
| Corona..... | Highest..... | 112 | 114 | 115 | 118 |
| | Lowest..... | 60 | 65 | 59 | 70 |
| Escondido..... | Highest..... | 108 | 101 | 101 | 105 |
| | Lowest..... | 55 | 58 | 55 | 60 |
| El Cajon..... | Highest..... | 113 | 103 | 106 | 103 |
| | Lowest..... | 57 | 59 | 56 | 61 |
| Indio..... | Highest..... | 123 | | | |
| | Lowest..... | 83 | | | |
| Los Angeles..... | Highest..... | 100 | 99 | 97 | 105 |
| | Lowest..... | 68 | 69 | 68 | 69 |
| Mecca..... | Highest..... | 124 | | | |
| | Lowest..... | 83 | | | |
| Mount Wilson..... | Highest..... | 92 | 94 | 95 | 98 |
| | Lowest..... | 69 | 68 | 70 | 70 |
| Needles..... | Highest..... | 115 | 118 | 118 | 120 |
| | Lowest..... | 64 | 66 | 68 | 70 |
| Pasadena..... | Highest..... | 106 | 107 | 108 | 113 |
| | Lowest..... | 59 | 62 | 60 | 71 |
| Pomona..... | Highest..... | 110 | 112 | 115 | 117 |
| | Lowest..... | 52 | 55 | 53 | 61 |
| Redlands..... | Highest..... | 108 | 111 | 113 | 114 |
| | Lowest..... | 64 | 66 | 64 | 73 |
| Riverside..... | Highest..... | 112 | 114 | 118 | 117 |
| | Lowest..... | 55 | 59 | 57 | 67 |
| San Bernardino..... | Highest..... | 110 | 112 | 114 | 116 |
| | Lowest..... | 55 | 57 | 58 | 73 |
| Santa Barbara..... | Highest..... | 92 | 105 | 105 | 115 |
| | Lowest..... | 48 | 57 | 63 | 66 |
| San Diego..... | Highest..... | 87 | 77 | 82 | 85 |
| | Lowest..... | 61 | 62 | 60 | 60 |
| Tustin..... | Highest..... | 107 | 97 | 94 | 96 |
| | Lowest..... | 43 | 50 | 52 | 55 |
| Whittier..... | Highest..... | 111 | 105 | 103 | 111 |
| | Lowest..... | 54 | 58 | 57 | 60 |
| Upland..... | Highest..... | 106 | 109 | 111 | 115 |
| | Lowest..... | 62 | 64 | 63 | 71 |

TABLE 2.—Monthly and annual distribution of temperatures of 100° F. and over at Los Angeles, Cal., 1877-1917.

| Year. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Number. |
|-------------|------|------|-------|-------|------|-------|------|---------|
| | °F. | °F. | °F. | °F. | °F. | °F. | °F. | |
| 1878..... | | | | | 103 | | | 1 |
| 1879..... | | | 104 | | 101 | | | 4 |
| 1881..... | | | | | 100 | 102 | | 2 |
| 1882..... | | | | | | 100 | | 1 |
| 1883..... | | 100 | 100 | | | 104 | | 6 |
| 1884..... | | | | | 102 | | | 2 |
| 1885..... | | | | | 106 | 108 | 102 | 5 |
| 1887..... | | | 100 | | | | | 1 |
| 1889..... | | | | | | 108 | | 1 |
| 1890..... | | | 105 | | | | | 2 |
| 1891..... | | | | 109 | | 100 | | 4 |
| 1895..... | | | 100 | | | | | 1 |
| 1896..... | | 103 | | | | | | 1 |
| 1899..... | | | | | | | 100 | 1 |
| 1905..... | | | | | 101 | | | 1 |
| 1906..... | | | | | | 105 | | 1 |
| 1907..... | | | | 103 | | | | 3 |
| 1909..... | | | | | 101 | 103 | | 3 |
| 1910..... | 100 | | | | | | | 1 |
| 1912..... | | | | | | 100 | | 1 |
| 1913..... | | | | | | 108 | | 1 |
| 1917..... | | | 105 | | | | | 2 |
| Number..... | 1 | 2 | 9 | 6 | 8 | 17 | 2 | 45 |

° Also 100°. ° Also 102°. ° Also 104°. ° Also 101°. ° Also 103°. ° 102° twice.
The extreme highest temperature, 109°, was registered on July 25, 1891.